

# Preventing Pollution

## ECONOMICAL METHODS FOR MAKING NEW FUELS FROM COAL

- Almost 90 percent of coal mined in the United States goes to power plants to produce electricity. Ideally, power plants desire high-energy-density (high-heating-value), low-sulfur, low-ash coal for operational and environmental performance considerations.
- Typically, eastern and mid-western U.S. coals are bituminous coals with inherent high heating value, but they often contain high levels of sulfur. Western U.S. coals, on the other hand, are largely subbituminous or lignite and are characteristically low in energy density (low-rank), but also low in sulfur content.
- Both eastern/mid-western and western U.S. coals have some percentage of unwanted mineral matter. The mineral matter contains metallic trace elements identified as hazardous air pollutants when released to the environment upon combustion.
- The CCT Program technologies enhance utilization of our vast coal resources by transforming them into clean, high-quality fuels and by providing users with the tools to select the most cost-effective clean fuel option for specific boilers.
  - Technologies are converting low-rank western coals, which contain up to 40 percent water, to dry, stable high-heating-value solid fuels and clean liquid fuels. This improvement significantly lowers transportation and handling costs and makes the western coal fuels viable in the larger, but distant mid-western and eastern power generation sectors.
  - For the eastern and mid-western coals, the focus of the CCT Program is demonstration of a conversion process that takes high-sulfur bituminous coal and produces methanol and other compounds for use as a fuel or chemical feedstock.

### *Clean Coal Fuels:*

- *Prevent pollutant emissions from forming by removing precursors from the source,*
- *Enhance power generation efficiency by improving fuel quality, and*
- *Allow full utilization of the nation's largest fossil energy resource without compromising the environment.*



Tank car loading facility for Coal Derived Liquid® at ENCOAL demonstration plant

## CONVERTING LOW-RANK COALS

The ENCOAL demonstration plant near Gillette, Wyoming uses a unique mild gasification process to convert low-rank coals into two valuable fuels: a clean coal-derived liquid (CDL<sup>®</sup>) that can be directly substituted for boiler fuels, and a clean, dry process-derived fuel (PDF<sup>®</sup>) for utility boilers that can meet CAAA standards without additional pollution control equipment. The ENCOAL project is demonstrating SGI International's Liquids-From-Coal (LFC<sup>®</sup>) process.

The product fuels proved to be economic in a broad range of commercial boiler applications and reduced SO<sub>2</sub> and NO<sub>x</sub> emissions significantly at utility and industrial facilities currently burning high-sulfur bituminous coal or fuel oil.

The PDF<sup>®</sup> contains 0.36 percent sulfur and has a heating value of 11,200 Btu/lb, whereas feed coal contains 0.45 percent sulfur and has a heating value of 8,400 Btu/lb. The CDL<sup>®</sup> contains 0.6 percent sulfur and has a heating value of 140,000 Btu/gallon, whereas the No. 6 fuel oil has a sulfur content of 0.8 percent sulfur and a heating value of 150,000 Btu/lb. The fuels contain no EPA-listed toxins in concentrations anywhere near the federal limits.

The plant officially entered production in June 1994 at a coal feed rate of 500 tons per day. By the end of the demonstration, nearly 260,000 tons of coal had been processed into more than 120,000 tons of PDF<sup>®</sup> and 121,000 barrels of CDL<sup>®</sup>. Over 83,500 tons of specification PDF<sup>®</sup> had been shipped to seven customers in six states, as well as 203 tank cars of CDL<sup>®</sup> to eight customers in seven states. PDF<sup>®</sup> also showed promise as a reductant in the direct iron ore reduction process and as a blast furnace injectant.

The ENCOAL demonstration plant proved the commercial feasibility of the SGI International Liquids-From-Coal (LFC<sup>®</sup>) process. The plant also attracted a large number of international visitors, especially from Pacific Rim countries, interested in either using the technology with their own coal supplies or purchasing the derived products. Partners in the project completed five detailed commercial feasibility studies—two Indonesian, one Russian, and two U.S. projects. Permitting of a 15,000 metric-ton/day commercial plant in Wyoming is nearly complete.

ENCOAL Demonstration Plant





The Rosebud SynCoal® Plant

The Rosebud SynCoal® plant, adjacent to the Rosebud coal mine in Colstrip, Montana, is demonstrating another route to producing high-quality fuel from low-rank coals. This advanced coal conversion process (ACCP) upgrades low-rank coal (with moisture contents of 25-40 percent, sulfur contents of 0.5-1.5 percent, and heating values of 5,500-9,000 Btu per pound) to SynCoal® with a moisture content as low as 1 percent, sulfur content as low as 0.3 percent, and heating value up to 12,000 Btu per pound.

The process uses combustion gases, devoid of oxygen, to drive off moisture, volatile organic sulfur, and other unwanted compounds; to mitigate spontaneous combustion by changing surface characteristics; and to fracture the coal, liberating ash.

The plant has the capacity to process about 1,800 tons of raw coal per day. By September 1999, more than 1.4 million tons of SynCoal® had been produced. Nearly 1.3 million tons has been supplied to industrial applications (primarily cement and lime plants) and utilities.

Rosebud SynCoal® Partnership continues to operate under an 8-year contract to supply SynCoal® to Montana Power's 330-MWe Colstrip No. 2, using a dedicated pneumatic feed system. The SynCoal® product both enhances boiler efficiency and reduces SO<sub>2</sub> emissions.

Rosebud SynCoal® Partnership has also signed a technology marketing agreement with Ube Industries, Ltd., of Tokyo, Japan. Under the agreement, Ube Industries has been granted a non-exclusive right to represent Rosebud in marketing and commercialization of the SynCoal® technology outside the United States, including Thailand, the Philippines, and Indonesia.



## CONVERTING BITUMINOUS COALS

The Air Products Liquid Phase Conversion Company, L.P., is demonstrating the Liquid Phase Methanol (LPMEOH™) process to produce methanol from coal-derived synthesis gas. Air Products and Chemicals, Inc., and the Eastman Chemical Company have formed a limited partnership to manage and execute the demonstration project, which is located at Eastman Chemical's integrated coal gasification facility in Kingsport, Tennessee.

The LPMEOH™ process has been developed to enhance integrated gasification combined-cycle power generation facilities by co-producing a clean-burning storable liquid fuel from coal-derived synthesis gas. The production of dimethyl ether (DME) as a mixed co-product with methanol will also be demonstrated. Methanol and DME may be used as a low-SO<sub>2</sub>, low-NO<sub>x</sub> alternative liquid fuel, a feedstock for the synthesis of chemicals, or new oxygenate fuel additive.

The process differs from other commercial methanol processes in that catalysis occurs in a liquid phase, which allows effective process heat removal. This feature permits the direct use of synthesis gas (derived from gasification of high-sulfur bituminous coal) as feed to the reactor without the need for phase-shift conversion.

The first stable operation of the unit at nameplate capacity of 80,000 gallons per day was achieved in April 1997 only four days after start-up. A test period at methanol production rates over 92,000 gallons per day revealed no system limitations.

During 1998 and 1999, the demonstration unit operated at an availability of over 99 percent. Operation at design catalyst loadings over 151 percent produced no indications of mass transfer limitations. Catalyst life has met or exceeded the design target. Since start-up, the demonstration facility has produced over 35 million gallons of methanol, all of which has been accepted by Eastman Chemical Company for use in downstream chemical processing.

A recent economic study of the LPMEOH™ process as an addition to an IGCC power plant indicates that cost-savings are realized when utilities manufacture and sell co-products: electricity and methanol. Costs compare favorably to those at new world-scale chemical-grade methanol plants.



LPMEOH™ installation at Eastman Chemical Company

## COAL FUEL SELECTION TOOL

ABB Combustion Engineering, Inc. and CQ Inc. have demonstrated a computer model that provides coal-burning utilities with a predictive tool to assist in selecting optimum quality coal for a specific boiler, based on operational efficiency, cost, and environmental emissions. The Coal Quality Expert® (CQE®) model can predict the operating performance of coals that previously have not been burned at a plant. The CQE Acid Rain Advisor, released in 1993, is a stand-alone tool for utilities to evaluate planning and CAAA compliance strategies.

A CD-ROM containing CQE® software was issued in December 1995. The Electric Power Research Institute (EPRI) owns the software and distributes it to EPRI members for their use. CQE® is available to others in the form of licenses. CQ Inc. (EPRI's licensing agent) and Black & Veatch have each signed commercialization agreements that give both companies non-exclusive worldwide rights to sell users' licenses and to offer consulting services that include the use of CQE® software.

More than 35 U.S. utilities and one U.K. utility have received CQE® through their EPRI membership. Two modules of the Acid Rain Advisor valued at \$6,000 have been sold. Proposals have been received from several non-EPRI-member U.S. and foreign utilities to license the software. It is estimated that CQE® saves U.S. utilities some \$26 million.

The CQE® team has a Home Page on the World Wide Web (<http://www.fuels.bv.com:80/cqe/cqe.htm>) to promote the software, facilitate communication between CQE® developers and users, and allow future software updates to be distributed over the Internet. The Web site also provides an on-line, updatable User's Manual. The site also helps attract the interest of foreign utilities as well as consulting firms.

*In 1996, the Energy Secretary and the EPRI President recognized the CQE® project as the best of nine DOE/EPRI cost-shared utility research and development projects under the Sustainable Electric Partnership Program.*

